Optimization for Satellite WANs

Improve Performance and Reduce Bandwidth Costs
Introduction

Satellite networking is an essential component of modern communications infrastructure for many government entities, international organizations, and civilian commercial enterprises. Whether for logistics operations, intelligence or simply as a backup to a terrestrial WAN, satellite communication transcends geographic and terrestrial infrastructure limitations to support these services.

But along with the value of satellite communications come its intrinsic limitations. Not simply an extension of the terrestrial WAN, the space segment of the network is burdened with a unique set of environmental, financial and operational conditions. The high cost and scarcity of satellite bandwidth requires careful budgetary planning and scheduling. The many sources of performance loss in satellite networking can create bottlenecks on the WAN, causing network inefficiency and degraded user experience. The nature of the satellite WAN requires satellite-specific technology solutions that can mitigate or eliminate these problems and bring it more in line with the behavior of the other segments of the enterprise.

The investments required for a satellite network demand that its performance be maintained at the highest possible levels. To that end, Riverbed Technology offers its line of satellite WAN optimization technology products. Designed to overcome the common sources of performance loss associated with space networking, Riverbed’s WAN optimization products actually allow for more-effective utilization of satellite channels, while providing improved user experiences and increased productivity. The resulting increased operational efficiency and deferment of bandwidth upgrades deliver financial savings. Riverbed’s satellite-specific technologies provide for high performance even under high bit error rate conditions and deliver a customized satellite solution, perfectly adapted to the needs of the federal and military satellite networking community as well as commercial enterprises.

Challenges: Bandwidth, Latency and Packet Loss

Organizations looking to better utilize their satellite communications can face a variety of environmental and operational obstacles. The first is often the availability of bandwidth. Many satellite networks are constrained by either the unavailability of satellite bandwidth in their operating region, or on their preferred satellite. In other cases, they simply do not have the budget for needed bandwidth upgrades. As a result, the IT administrator is often faced with the challenge of doing more with less—supporting more operational requirements over satellite without the budget to procure more bandwidth. This constraint can be particularly difficult when organizations look to expand the role of satellite to support operations commonly performed over the LAN or terrestrial WAN.

While the challenge with bandwidth is that there is often too little available bandwidth on satellite links, latency provides the opposite challenge in that there is too much of it in these environments. Round-trip latency is defined as the time it takes for a data packet to traverse the satellite WAN, from source to destination, and back again. Latency is commonly measured in milliseconds and is based on a number of factors, chief among them being the physical distance between the devices. In land-based communication networks, the distance between the client and the server varies considerably. In the case of a geosynchronous satellite at an altitude of 22,000 miles, round-trip latency is 540 ms, and often reaches 700 ms and beyond when other networking factors are introduced. For double-hop satellite connections the latency can reach a full second or more.

Performance loss in these connections, however, is the result of more than just the physical distance between device endpoints. Satellite traffic often suffers high rates of packet loss from a variety of causes, including weather, power outages, blockage, and interference. High error rates can increase network transaction speeds to intolerable levels, frequently resulting in retransmissions, timeouts, and badly degraded user experiences.
Compounding the problem are the protocols at the application layer. Many of these applications are “chatty,” requiring a high volume of small packet back-and-forth transfers to complete a transaction. With each transfer requiring a half second round trip time, even a simple file transfer could take minutes to complete over a geosynchronous link.

High latency, matched with protocols designed for land-based systems, means that organizations engaged in satellite communications suffer degraded performance. Some IT departments mistakenly assume the problem is the result of constrained bandwidth, and pour more resources into increasing the size of their satellite channels. However, more bandwidth does nothing to mitigate latency or modify the protocols that high latency degrades; even with the added cost of more bandwidth, the performance remains unchanged.

**SkipWare®: Improved performance for satellite WANs**

Recognizing the importance of satellite performance for its fighting force, the U.S. Department of Defense (DoD) initiated a joint industry partnership to develop a common standard protocol for Internet-over-satellite communications. Through a collaborative, multi-year R&D effort, the partnership created the Space Communications Protocol Standards-Transport Protocol (SCPS-TP, commonly referred to as ‘skips’). SCPS required a basic rethinking of IP transport, and represented the first major development in developing a satellite-specific WAN optimization technology.

Unlike TCP, the SCPS protocol was designed to operate in an environment of high-latency and limited bandwidth. The first commercial implementation of the SCPS protocol was released under the brand name SkipWare®, now an exclusive technology in the Riverbed® product family. A pioneering product in the SCPS community, SkipWare is responsible for most of the industry firsts associated with SCPS, and is largely credited for the widespread adoption of the protocol today. Expanding on the early work done by the SCPS consortium, SkipWare goes far beyond the original capabilities of the protocol to become the robust, full-featured technology solution it is today.

SkipWare provides many tools and performance features that build on the original specification of the SCPS protocol. Perhaps its greatest differentiator is SkipWare’s ability to operate seamlessly with modern modem technologies. The proliferation of dynamic bandwidth transmission systems, such as TDMA and DVB, presents a unique challenge to WAN optimization technologies. As bandwidth allocation changes over the network, WAN optimization technologies must be able to automatically detect these changes and respond accordingly. SkipWare is designed to sense increases and decreases in bandwidth allocation and automatically adjust its transmission window in response, without requiring user intervention.

SkipWare has also been designed to provide rapid recovery from packet loss, allowing users to operate at high levels of bandwidth efficiency even over very “dirty” links. Specialized recovery mechanisms such as Selective Acknowledgments (SACK) and Selective Negative Acknowledgments (SNACK) have been built into SkipWare to recognize packet loss on the network, but respond by simply marking lost packets for later retransmission. Only under extreme circumstances does SkipWare reduce its transmission window in response to loss, maintaining line rates even with high bit errors and packet reordering. These loss-resistance techniques, combined with SkipWare’s other layer-4 optimization features, provide the perfect complement to, and increase the overall performance of Riverbed optimization technologies over an errored satellite channel.

SkipWare’s response to latency allows it to operate at high bandwidth efficiencies over single-hop, double-hop, and even higher-hop satellite channels. The standard behavior of TCP is to interpret high round trip times as signaling...
network congestion, and reduction the transmission window. Reducing the window is an effective remedy over a terrestrial WAN; but over a satellite channel, where high round trip times are the norm such a response prevents TCP from ever fully utilizing the link. SkipWare is designed to keep its transmission window open even under high latency conditions, and only make adjustments when there are substantial changes to the round trip time. The net result is that SkipWare keeps the pipe full, allowing every application to be serviced with bandwidth equally and efficiently.

**The Riverbed Optimization System (RiOS)**

Even with SkipWare deployed, satellite networks still face a number of performance challenges associated with the inherent limitations of common applications over high latency, constrained bandwidth channels. To solve these challenges, the Riverbed Steelhead appliance offers a full-featured acceleration package for satellite networks that serves as the perfect complement to SkipWare. Where SkipWare leaves off, the Riverbed Optimization System (RiOS) picks up. RiOS is the operating system that powers Steelhead appliances, and provides multi-layer WAN optimization and lowers bandwidth utilization via data deduplication. The industry-leading application and protocol optimization capabilities in RiOS provide agencies LAN-like performance over satellite connections, with out-of-the-box compatibility over any satellite network.

While SkipWare is a comprehensive layer-4 solution for satellite, Riverbed offers other optimizations that are also effective over satellite channels. TCP optimization techniques such as connection pooling, local acknowledgements, and increased payload size can have a dramatic effect in a satellite environment. Riverbed also natively supports Loss Tolerant Transport over Satellite (LTTS) and TCP Westwood – a sender-side TCP variant that is effective in calculating optimal transmission window sizes.

Application protocol streamlining reduces the chattiness of traditional client-server applications. Optimizing application behavior by read-aheads and write-backs for file sharing protocols such as CIFS, or pre-populating users' mailboxes for MAPI, are just a couple of examples of how application protocols can be optimized over WANs.

In addition to the WAN optimization features that operate at the protocol level, Riverbed Steelhead appliances also provide a feature known as scalable data referencing (SDR). This process uses intelligent algorithms to recognize data patterns as they transit the network, and eliminate redundancies.

A combination of these techniques cuts, a file transfer that might take minutes down to a matter of seconds

<table>
<thead>
<tr>
<th>File Size and Protocol</th>
<th>No Optimization</th>
<th>RiOS Only</th>
<th>RiOS + Skipware</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.8MB FTP</td>
<td>328.6 sec</td>
<td>4.65 sec</td>
<td>0.6 sec</td>
</tr>
<tr>
<td>12.2MB FTP</td>
<td>598.4 sec</td>
<td>5.8 sec</td>
<td>0.7 sec</td>
</tr>
<tr>
<td>100MB FTP</td>
<td>3644.32 sec</td>
<td>14 sec</td>
<td>9 sec</td>
</tr>
<tr>
<td>162MB FTP</td>
<td>6122.45 sec</td>
<td>22 sec</td>
<td>15 sec</td>
</tr>
</tbody>
</table>

*Figure A: File transfer times with varying file sizes over a 6Mbps link with 580ms latency*

**Riverbed in the Satellite Architecture**

Riverbed appliances are well suited for hub and spoke architectures, as well as in point-to-point, or full or partial mesh networks. RiOS was designed with scalability in mind, so that even as the number of remotes extends into the 1000s and beyond, Steelhead network performance will be unimpeded. Individual Steelhead appliances range from small-form factor devices that run at speeds as low as 1 Mbps, up through enterprise class Steelheads with rates in excess
of 1 Gbps and supporting up to 100,000 simultaneous connections. A cluster of Steelheads can support 12 Gb/s and 1 million simultaneous connections.

But where an appliance is not appropriate for the network, Riverbed offers software-only implementations of the Steelhead appliance, which can be inserted into the network with identical performance results. Steelhead Mobile™ is a software implementation of the Steelhead designed to run on an end user system as a software client. Working seamlessly with other Steelhead devices, Steelhead Mobile is ideal for individual remote users, or satellite connections where size, weight and power constraints make appliance-based optimization impractical. Similarly, Virtual Steelhead™ is a virtualized instance of the RiOS feature set. Because each of these instances of the Steelhead is fully interoperable, they can be deployed across a network, as the architecture requires, without sacrificing performance or compatibility.
Conclusion

Riverbed recognizes that the satellite segment of the network has different attributes than the terrestrial WAN, and requires a different technical approach. While it is possible to adapt WAN optimization technologies intended for the larger enterprise WAN market into the satellite space, and benefit from performance improvement, SkipWare adds another layer of optimization for links, with latencies as high as 10x those of the terrestrial WAN, and bit error ratios that would be considered catastrophically high on a wired network.

By focusing on the critical behaviors at layer-4, and adapting the behavior of their TCP implementations to the loss, latency and dynamic bandwidth conditions of the satellite network, Riverbed has created the foundation for a satellite-specific WAN optimization solution. With SkipWare at the forefront of Riverbed’s satellite technology options, users can be assured of both high performance and DoD standards compliance. And given the broad range of deployment options, including both appliance-based and software implementation options, Riverbed provides the performance, architectural flexibility, and scalability necessary to keep federal, military and commercial satellite networks running at peak efficiency.

About Riverbed

Riverbed delivers performance for the globally connected enterprise. With Riverbed, enterprises can successfully and intelligently implement strategic initiatives such as virtualization, consolidation, cloud computing, and disaster recovery without fear of compromising performance. By giving enterprises the platform they need to understand, optimize and consolidate their IT, Riverbed helps enterprises to build a fast, fluid and dynamic IT architecture that aligns with the business needs of the organization. Additional information about Riverbed (NASDAQ: RVBD) is available at www.riverbed.com.